attention to the subject, and cannot find any limits (taking all Europe into consideration) to its range within the Lower Carboniferous rocks. In England, however, it has never yet been recorded from beds of Tuedian age, nor, taking into account the nature of the Tuedian deposits, is it very likely that it may ever be found in them.

V.—On the Occurrence of a Mineral Allied to Enstatite in the Ancient Lavas of Eycott Hill, Cumberland.

By Professor T. G. Bonney, D.Sc. LL.D., F.R.S., Pres. G.S.

THIS interesting series of ancient volcanic rocks is described by the late Mr. Clifton Ward in a paper on the Microscopic Structure of Ancient and Modern Volcanic Rocks, read before the Geological Society,[1] in a Memoir of the Geological Survey on the Lake District, and, in greater detail, in a communication to the Royal Microscopical Society.[2] All these are illustrated by figures (in no case very good) and some chemical analyses are given in the last-named paper. I went to the hill in the autumn of 1874 and collected a few specimens, but my visit was cut short by heavy rain. A few weeks since Mr. J. Postlethwaite of Keswick, to whose kindness I have been more than once indebted for additions to my collection, forwarded to me three specimens from Eycott Hill, thinking that I might not have any rocks therefrom, and called my attention to the peculiar reddish tint of the felspar in one of them, which, as he remarked, "resembled the colour of a garnet." These were varieties of the well-known porphyritic lava of Eycott Hill, which is described by Mr. Ward as the second lava bed in ascending order, and as being above 100 feet thick. This specimen was obtained from a boulder on the hill. On examining it and comparing it with my own (at which I had not looked for some years), I was struck with the appearance of the ground-mass, which seemed to me unusually compact and more like that of an augite-andesite, than of a dolerite or diabase, as the rock is named by Mr. Ward. I had a slide prepared by Mr. Cuttell from Mr. Postlethwaite's specimen, in which I first discovered the mineral which is described in this note, and have since had some more cut from my own specimens from Eycott and others subsequently sent by him, and (for comparison) from the lavas of Falcon Crag near Derwentwater.

The Eycott rock is described by Mr. Ward as having "a compact greenish-blue base, containing dark green spots of a soft mineral and large porphyritically imbedded felspar crystals, many of them an inch long. . . . . The top of this lava is beautifully vesicular in parts, the vesicles being drawn out along the line of flow and filled with chlorite, chalcedony, and calcite." The "dark green spots" I may add generally do not exceed ·1 inch in diameter, and I should be disposed to call the base a dark "slate" colour, commonly with a greenish tinge (slightly purplish in Mr. Postlethwaite's specimen), rather than a "greenish-blue"; the felspar crystals are in the normal specimens a greyish olive-green.

[1] Q.J.G.S. vol. xxxi. p. 406. [2] Monthly Microsc. Journal, 1877, p. 239.

The felspar crystals, with the above described greenish spots, and some grains of iron oxide, belong to an earlier stage of consolidation, or, possibly one should say, of crystal-building. As Mr. Ward points out, they cannot have been separated out of the mass when it flowed as a lava. I have little to add to his careful description, except that I believe these felspars to be labradorite, and doubt the possibility of any of them being orthoclase. In Mr. Postlethwaite's specimen a few scales of iron-glance are scattered about in the felspar crystals, but not in such numbers as one would expect from their ruddy tint before being sliced. The soft dark spots are regarded by Mr. Ward as pseudomorphs in many cases after augite, and some, he says, "seem to be after olivine, presenting the form and much-fissured appearance of that mineral. I have detected grains of olivine in an unaltered condition in some of these lavas, and therefore think there can be no doubt that both it and augite were common constituents at one time, though both have been so much replaced by pseudomorphous minerals through subsequent alteration." It is of course quite possible that my lamented friend may have detected olivine in some of the upper lavas, which I have not examined; but I think he has erred in his reference of these dark green spots either to augite or olivine, as will be seen from the following description. But I do not in the least doubt the presence of moderate-sized crystals of augite, which however seems to be always in fair if not good preservation, in addition to that which occurs in the ground-mass.

The mineral of which we speak is obviously a magnesian silicate, which has generally been converted, since the consolidation of the rock, into a kind of serpentine. In form it is usually a rather irregular oblong, about twice as long as it is broad, with a slightly worn or corroded aspect at its edges; and it is very commonly bordered by clustered opacite, as is frequent with hornblende and mica in an andesite. Hence the external crystalline form is generally not well defined. There is one well-marked cleavage parallel with the longer sides of the grain, with, I think, an indication of a second, which makes a large, if not a right angle with the other, and possibly a third; but these are often only suggested by the presence of rather irregular cracks, so that it is not possible to be certain about them. Indications of a fibrous structure, parallel with the dominant cleavage, may also be observed. With transmitted light the usual colour is a pale sap-green, but sometimes the inner, sometimes the outer part of the crystal is slightly browner. The mineral has evidently undergone alteration, but in one crystal a portion remains apparently unchanged, and this is of a pale greenish straw colour. All exhibit a fairly well-marked dichroism. When the principal cleavage lines are parallel with the vibration plane of the lower Nicol, the tint is a pale sap-green; when perpendicular, it is a pale yellowish-green. With crossed Nicols, extinction takes place when the dominant cleavage lines are parallel with either vibration plane; when they are at an angle of 45° with these, the colour in the unaltered part is a straw-yellow, the tints in the altered parts being paler, and such as are usual with serpentinous minerals. I notice that the browner

and greener parts mentioned above do not extinguish simultaneously. The mineral contains a few scales of iron-glance and some light brown granular endomorphs, which occur also in the ground-mass[1] but is generally rather free from inclusions. Obviously we have here a magnesian silicate containing some iron, which is more or less converted into a kind of serpentine. Clearly it is not olivine, neither is it normal bastite. It does not correspond with hypersthene, especially with the small crystals of that mineral which have of late been noticed in so many andesites. Its general aspect agrees with that of some of the more or less altered enstatites and bronzites with which I am familiar from my studies of serpentines, and it reminds me also of the representations given of altered enstatite and of so-called bastite by Fouqué and Lévy (*Mineralgie Microscop. Roches Eruptives Françaises*, plates xxvii., liii., and liv.)

The ground-mass, in which the above-described minerals are embedded, consists of lath-like crystallites of plagioclase felspar, of grains and imperfectly developed little crystals of augite, and of crystals and granules of iron-oxide, which probably is mostly hematite. There are occasional scales of iron-glance. These are thickly set in a brown glass-like base. This when examined with objectives of fairly high power—say from $\frac{1}{4}$ to $\frac{1}{8}$ of an inch—becomes paler and greyer in colour, and is found to be crowded with dark granules and blackish belonites, which are sometimes slightly curved. These occasionally seem to interlace so as to form a kind of network. Similar microliths, but with a brush-like grouping, are figured by Rosenbusch in a hydrotachylite[2] (*Microscop. Physiograph.* vol. i. plate iii.). These belonites occur in the slide prepared from Mr. Postlethwaite's specimen; in that from a specimen collected by myself they are, if not absent, exceedingly rare. The general character, however, of the ground-mass of the latter corresponds with that of the former. So far as I can ascertain, the base is still a true glass, and has not undergone devitrification.

After I had informed Mr. Postlethwaite of the result of my examination of his first specimen, he again visited Eycott Hill, forwarding to me fresh fragments of the redder variety broken from the rock *in situ*, and then a block, also obtained *in situ*, which exhibited a passage from that variety to the normal rock. I have had a slide cut from the extreme parts of this, for the transition from the one tint to the other is too gradual to offer anything like a junction. The two slides when examined under the microscope are almost identical, the only difference being that in the redder variety small scales of burnt-sienna coloured iron-glance are more numerous, and in its ground-mass the dark belonites are more frequent than in the normal rock. Also I think that the base of the former, when viewed with a low power, is a shade browner than that of the latter. The description given above serves as a whole for these slides also. Each,

[1] They are not isotropic. Probably they are alteration products, possibly ferruginous. They often occur in somewhat altered igneous rocks.

[2] Similar needles are figured by Prof. Judd and Mr. Cole in their admirable paper on the Basalt Glass of the Western Isles of Scotland, Q.J.G.S. vol. xxxix. p. 444.

I may remark, contains some sections of the supposed altered enstatite. Many of these exhibit one well-marked and fairly frequent cleavage, with two others much less perfectly developed; one being very nearly at right angles to, and the other making an angle of about 26° or 27° with the first. Thus these two include between them an angle not far from 60°, but where the principal cleavage is not visible in the slice, then the irregular cracks appear to meet much more nearly at right angles. The slide from the normal rock contains five or six crystalline grains, roughly clustered together. Not one has quite escaped change, but in several we see a rather broad fibrous-looking border of a pale green colour, which gives uniform and clear tints with the crossed Nicols, while the interior is confusedly fibrous in structure and in large part dark, besides being a rather stronger green colour with ordinary light. Here and there we have a grain which is not much more altered than the one already described.

Above the porphyritic lava just described comes a series of lavas noticed in Mr. Ward's paper. I possess a specimen from the lowest of these (I believe that numbered 6 in his section). It is porphyritic, but the felspar crystals are much smaller than in the other rock, not generally exceeding a quarter of an inch in the longer diameter. These under the microscope appear to be more broken and corroded than they are in the rock below. The altered "enstatite" is also present in about the same quantity, but it too has a slightly more corroded aspect and is more thickly black-bordered than in the other. The ground-mass is of the same general character, but the crystallites are smaller, and the base, which with a low power is darker, seems to be of a green hue, and more crowded with microliths. The dark border of the enstatite also seems to be resolved into minute granules of a partly translucent mineral, probably augite, mingled with ferrite.

In the lowest of the lavas at Falcon Crag I find a little of what I believe to be the altered enstatite, though it is much more irregular in form, more interrupted by inclusions, and altogether less well characterized than at Eycott Hill, so that I should hardly have ventured on identifying it from these slides. In this lava there is also a fair quantity of well-preserved and characteristic augite (diameter commonly about ·03 to ·05 inch). I do not detect the enstatite in either of the slides from the next two lava-flows.

I think then there can be no doubt that the Eycott Hill lavas contain a variety of enstatite. It might be possible, but it would be difficult, to isolate a sufficient quantity for chemical analysis, but to my mind the evidence as to its nature is already sufficiently clear, and the only point on which we require enlightenment is whether enstatite or bronzite would be the better name. The settlement of this point I willingly leave to any one who thinks it worth the time and labour, for I feel confident that the mineral is a bisilicate of magnesia with some iron.

From the aspect of the ground-mass of the Eycott Hill rock, and the presence of the bisilicate, enstatite, instead of the unisilicate, olivine, I should not have been surprised if it had proved to be chemically more nearly related to the Falcon Crag lavas than to those

which succeed it at Eycott Hill. Analyses of the latter, quoted by Mr. Ward in the paper mentioned above, show the silica percentages of three of them to be respectively 53·3, 52·6 and 51·1. The Falcon Crag rocks are shown by Mr. Ward (though he coined for them the unhappy term *felsidolerite*) to be in reality andesites, which microscopically and chemically[1] present only such differences from the modern representatives of that group as we should naturally expect in rocks of such great antiquity. By the kindness of Prof. A. W. Williamson, the silica percentage of the red variety of the Eycott Hill rock has been determined for me by Mr. T. Cooksey in the laboratory of University College. He finds it to be 53·06 (one determination giving 53·40 another 52·73)[2] with a specific gravity of 2·754. The rock must therefore remain among the basalts (the glassy condition of its base renders the name dolerite inappropriate). It belongs, however, to the side of the basalt group which is the richer in silica, and is nearly represented among modern rocks by some of the basalts of the Inner Hebrides in Prof. Judd's collection. It also resembles in certain respects some of the magma basalts described by Boricky (*Petrographische Studien an den Basaltgesteinen Böhmens*). The amount of alteration may justify us in naming it now an enstatite-diabase, but I feel no doubt that it was originally a true basalt rich in glass, containing a variety of enstatite.

REVIEWS.

Dr. Fritsch's Permian Amphibians of Bohemia.

DR. ANTON FRITSCH has now made such progress with his Monograph on the Fauna of the Bohemian Permian rocks that we are able to recognize it as one of the most important and one of the ablest of modern contributions to Palæontology. For excellence of description it has not been surpassed; while from the minute dimensions of most of the Amphibian remains, care has been required in deciphering osteological characters, which has resulted in a perfection of osteological labour. Specimens offering fewer difficulties might not perhaps have been studied with the same completeness. Professor Fritsch has shown that he is a learned comparative anatomist, whose wealth of knowledge has enabled him to enrich his pages with the fruits of many and varied studies, and to successfully interpret remains which are often obscure.

The third part of the work contains descriptions of *Urocordylus scalaris, Keraterpeton crassum, Limnerpeton modestum, L. laticeps, L. macrolepis, L. elegans, L. obtusatum L. dubium, L. difficile,* and a note on *L. caducum.* Like the foregoing part it consists of 32 quarto pages of text, well illustrated by many excellent figures printed with the text; and by 12 coloured plates.

The memoir begins with some account of the family Nectridea,

[1] Two analyses of lavas from the Keswick district given in the Survey Memoir give silica percentages of 60·718 and 59·511 respectively.

[2] He also writes, "The rock contains a small amount of calcium, less magnesium, but mainly iron, aluminium and silica."